Developing a digital twin of two robot arms to simulate docking procedures in space

(Placement opportunity for Dr John Oyekan at the Satellite Applications Catapult)

Challenge: Spacecraft docking for in-orbit services and manufacturing (IOSM), e.g., resupply, retrieval and so on will become a necessity as activities in space increase. The Satellite Applications Catapult is developing a two-robot simulator that enables testing and validation of capabilities for IOSM functions. However, understanding and configuring the appropriate means of propulsion to send to a spacecraft that needs to dock with another is difficult to know in advance, especially when the receiving spacecraft has an unknown and unpredictable motion profile. The challenge is to develop a digital twin environment that can be used to replicate the motions of spacecraft in space and to test them out on earth before deployment in space. The idea is to translate the trajectories that a spacecraft's guidance & navigation systems (GNC) produce into robot arm motions thereby replicating the spacecraft's motion in a safe environment.

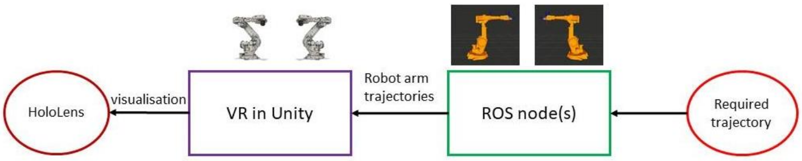


Figure 1. Showing the scope of placement work

Proposal: This work placement aims to develop a digital twin of two robot arms. One robot will simulate the receiving spacecraft and the other robot will simulate the chasing or docking spacecraft. The idea will be to send various trajectory (**required trajectory oval** in Figure 1) profiles to the "receiving robot arm" while the "chasing robot arm" would aim to sense and match the profile for a docking procedure.

Figure 2. Pose estimation of objects

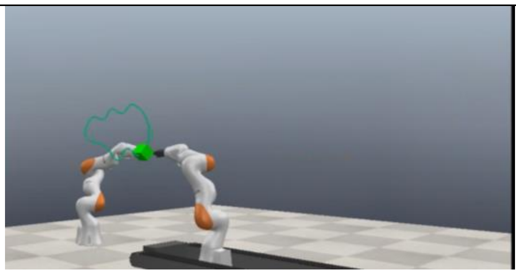
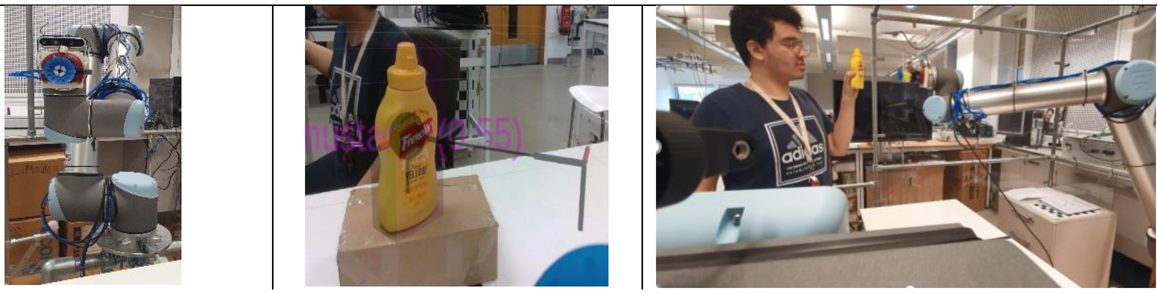


Figure 3. A robot arm tracking the object on another arm using RGB-D cameras in simulation

Progress: We configured a Deep Neural Network to enable Deep Object Pose Estimation of objects as shown in Figure 2. We created two robot arms in which one robot chasing chased an object held on another robot arm (Figure 3). The 3 steps were designed and programmed into the chase robots as follows: (1) Observation and planning phase; (2) Final approach phase and (3) Pre-grasping phase. We tested our approach in simulation as shown in Figure 3 and on a physical robot as shown in Figure 4.



(a) Robot with gripper **(b)** A representative object to grasp **(c)** The robot arm tracking an object.

Figure 4. Experiments showing a physical robot tracking an object's pose.

Next steps: The next steps are to deploy our approach onto physical robots at the Satellite Catapult Network as well as to continue to develop the Virtual Reality environment in Unity3D (See purple box in Figure 1) for immersive visualisation.